PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2003-087085

(43)Date of publication of application : 20.03.2003

---

(51)Int.Cl. H03H 9/17

H01L 41/08

H01L 41/09

H01L 41/18

---

(21)Application number : 2002-139863

(22)Date of filing : 15.05.2002

(71)Applicant : MURATA MFG CO LTD

(72)Inventor : TAKEUCHI MASAKI
YAMADA HAJIME
GOTO YOSHIHIKO
NOMURA TADASHI
YOSHINO YUKIO

---

(30)Priority

Priority number : 2001202135 Priority date : 03.07.2001 Priority country : JP

---

(54) PIEZOELECTRIC RESONATOR, FILTER AND ELECTRONIC COMMUNICATIONS EQUIPMENT

(57)Abstract:
PROBLEM TO BE SOLVED: To reduce a loss of a resonance energy at an electrode and to make the stability of a resonance frequency proper with respect to temperature changes.
SOLUTION: A piezoelectric resonator has a substrate 2, and a plurality of resonators formed on the substrate 2, each having a transducer 4 of a structure, in which at least a pair of upper electrode 4b and a lower electrode 4a, arranged opposed and sandwiched by the upper and lower surfaces of an inside thin film, having at least one or more piezoelectric thin film. The piezoelectric resonator further comprises one or more outside thin film 4c, including a piezoelectric thin film or a dielectric thin film under the lower electrode 4a, in such a manner that the transducer 4 oscillates in an oscillation mode of an n-fold wave (where n is an integer of 2 or larger) and the electrodes 4b and 4a are provided at positions of the antinodes of substantially n-fold waves.

LEGAL STATUS

[Date of request for examination]	26.09.2003
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	
[Date of registration]	
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against	

examiner's decision of rejection]

[Date of extinction of right]

CLAIMS

[Claim(s)]

[Claim 1] Have the oscillating section of the structure which the up electrode and lower electrode of a pair are made to counter at least, and faces across the vertical side of the inside thin film section which has the piezo-electric thin film of at least one or more layers currently formed in the substrate and said substrate. While having the outside thin film section of one or more layers which contains a piezo-electric thin film or a dielectric film under said lower electrode in the piezo resonator which prepared two or more resonators Said oscillating section is a piezo resonator characterized by what it vibrates by the oscillation mode of a wave (however, n two or more integers) n times, and said up electrode and the lower electrode are prepared for in the outline and the location of the antinode of said n time wave.

[Claim 2] The piezo resonator characterized by what is set as the value to which said thickness ratio r carries out the resonance frequency temperature coefficient of the whole piezo resonator concerned near zero when it makes [the thickness of said outside thin film section] r=to/ti the thickness ratio of ti and both the thin

film section for the thickness of to and said inside thin film section in a piezo resonator according to claim 1, said n time wave having been used as 2 double wave.

[Claim 3] The piezo resonator characterized by what is considered as the combination which has the resonance frequency temperature coefficient from which each thin film differs mutually in either [at least] said inside thin film section or the outside thin film section in a piezo resonator according to claim 1 or 2.

[Claim 4] The piezo resonator characterized by what is consisted or more of at least one of the thin film with which said outside thin film section uses SiO2 thin film as a principal component, the thin film which uses a SiN thin film as a principal component, and the thin films which use 2Oaluminum3 thin film as a principal component in a piezo resonator according to claim 1 to 3.

[Claim 5] The piezo resonator characterized by what is consisted or more of at least one of the thin film with which said inside thin film section uses ZnO as a principal component, the thin film which uses AlN as a principal component, the thin film which uses titanic-acid lead zirconate as a principal component, the thin film which uses lead titanate as a principal component, and the thin films which use barium titanate as a principal component in a piezo resonator according to claim 1 to 4.

[Claim 6] It is the piezo resonator characterized by for said substrate having opening or a crevice in a piezo resonator according to claim 1 to 5, and forming said oscillating section on said opening or a crevice.

[Claim 7] The filter characterized by the thing have the plurality of a piezo resonator according to claim 1 to 6, and it comes to connect the electrodes in those piezo resonators to the configuration of a filter circuit.

[Claim 8] The filter characterized by coming to connect a piezo resonator according to claim 1 to 6 with plurality and a ladder mold.

[Claim 9] The duplexer characterized by being constituted using a filter according to claim 7 or 8.

[Claim 10] Electronic communication equipment characterized by what it has one or the plurality of a piezo resonator according to claim 1 to 6, and those piezo resonators are used for electronic communication link actuation for.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the piezo resonator which uses piezoelectric material and a dielectric material as a thin film, and forms an oscillating part as multilayer structure, in more detail, is used for a filter, a radiator, etc. and relates to a VHF band, a UHF band, and the piezo resonator that carries out thickness longitudinal oscillation in the ultrahigh frequency band beyond it further. This invention relates to the filter and electronic communication equipment which used this piezo resonator again.
[0002]
[Description of the Prior Art] In the case of the piezo resonator using thickness longitudinal oscillation, there are some which make it the gestalt which infixed the piezoelectric film with very thin thickness in inter-electrode using the resonance

frequency having a relation in inverse proportion to the thickness of a piezoelectric film, and obtain a resonance response in the number band of ultrahigh frequency.

[0003] In such a piezo resonator, there is a thing of the thickness longitudinal-oscillation mold equipped with the substrate which has opening which penetrated the front rear face, the diaphram which consists of SiO2 thin film in which said opening was prepared on this substrate with the wrap gestalt, and the oscillating part which comes to infix a ZnO thin film between the counterelectrodes of the pair prepared on said diaphram.

[0004] And there are some which lost the loss of the resonance energy in an electrode as a gestalt which exists the antinode of a fundamental wave in an electrode as structure which inserted the piezoelectric film into the electrode of a vertical pair, and made that resonance characteristic good in this kind of piezo resonator.

[0005]

[Problem(s) to be Solved by the Invention] However, since the fundamental wave was used in the case of the above-mentioned conventional piezo resonator and a resonance frequency temperature coefficient is sharply changed by thickness ratio fluctuation with said SiO2 thin film and ZnO thin film in the case of a fundamental wave though the loss of resonance energy decreases, resonance frequency tends to change a lot by the temperature change, therefore the stability of the resonance frequency to a temperature change is low.

[0006] Therefore, this invention makes it the technical problem which should be solved to reduce the loss of the resonance energy in an electrode, and to make good stability of the resonance frequency to a temperature change.

[0007]

[Means for Solving the Problem] This invention has the oscillating section of the structure which the vertical side of the inside thin film section which has the piezo-electric thin film of at least one or more layers currently formed in the substrate and said substrate is made to counter, and faces the up electrode and

lower electrode of a pair across it at least. While having the outside thin film section of one or more layers which contains a piezo-electric thin film or a dielectric film under said lower electrode in the piezo resonator which prepared two or more resonators It is characterized by for said oscillating section vibrating by the oscillation mode of a wave (however, n two or more integers) n times, and preparing said up electrode and the lower electrode in the location of the antinode of a wave an outline and said n times.

[0008] According to this invention, since the up electrode and the lower electrode are prepared in the outline and the location of the antinode of a n time wave, they can reduce the loss of the resonance energy in these electrodes. And by this invention, since a thickness ratio field where a resonance frequency temperature coefficient is not changed sharply exists even if it changes somewhat the thickness ratio of each of said thin film section by vibrating by the oscillation mode of a wave n times, stability of the resonance frequency is carried out to a temperature change by setting a thickness ratio as the field.

[0009] This invention is set as the value to which said thickness ratio r carries out the resonance frequency temperature coefficient of the whole piezo resonator concerned near zero, when it makes [the thickness of said outside thin film section] r=to/ti preferably the thickness ratio of ti and both the thin film section for the thickness of to and said inside thin film section, said n time wave having been used as 2 double wave.

[0010] Stability of the resonance frequency is carried out to a temperature change still more effectively by a wave being made into 2 double wave n times in such a case.

[0011] Let this invention still more preferably be the combination which has the resonance frequency temperature coefficient from which each thin film differs mutually in either [at least] said inside thin film section or the outside thin film section.

[0012] This combination includes both the combination between each thin film which constitutes the outside thin film section, and the combination between

each thin film which constitutes the inside thin film section and each outside thin film section, when the combination between each thin film which constitutes the inside thin film section when the inside thin film section consists of two or more thin films, and the outside thin film section consist of two or more thin films.
[0013] Since the resonance frequency temperature coefficient of the whole piezo resonator concerned can be set up near zero still more effectively in such a case, resonance frequency can be further stabilized to a temperature change.
[0014] This invention consists or more of at least one of the thin films with which said outside thin film section uses as a principal component the thin film which uses SiO2 thin film as a principal component, the thin film which uses a SiN thin film as a principal component, and 2Oaluminum3 thin film still more preferably.
[0015] This invention consists or more of at least one of the thin film with which said inside thin film section uses ZnO as a principal component, the thin film which uses AlN as a principal component, the thin film which uses titanic-acid lead zirconate (PZT) as a principal component, the thin film which uses lead titanate (PT) as a principal component, and the thin films which use barium titanate (BT) as a principal component still more preferably.
[0016] This invention is still more desirable, said substrate has opening or a crevice and said oscillating section is formed on said opening or a crevice. Here, opening means the space section in the condition of having penetrated the front rear face of a substrate. The space section which the crevice was dented in the shape of an owner bottom in the whole surface side of a substrate, and was formed is said. Thus, the resonance characteristic improves by forming the oscillating section on opening or a crevice.
[0017] From the above thing, according to this invention, small fluctuation of as opposed to [get it blocked and] the temperature change of resonance frequency of a resonance frequency temperature coefficient can be small controlled to fluctuation of thickness, and the piezo resonator by which the resonance response was extremely stabilized to the temperature change can be offered.
[0018] In addition, bringing the resonance frequency temperature coefficient as

the whole piezo resonator close to inter-electrode [of a vertical pair] at zero as structure which sandwiched the piezoelectric film which has a negative resonance frequency temperature coefficient, and the piezoelectric film which has a forward resonance frequency temperature coefficient, and attaining stabilization of the resonance response to a temperature change is indicated by JP,2001-203558,A.

[0019] Moreover, losing the loss of the resonance energy in an electrode on 0963040AEP2 specifications as a gestalt which exists the antinode of a resonance wave in an electrode as structure which inserted the piezoelectric film into the electrode of a vertical pair, and making the resonance characteristic good is indicated.

[0020] Moreover, carrying out the laminating of this piezoelectric film and the thin film of an opposite sign to inter-electrode [of a vertical pair] in the center of the thickness direction between the piezoelectric films of a pair, and making the temperature characteristic of resonance frequency good is indicated by JP,1-48694,B.

[0021] Like this invention, since the antinode of an oscillatory wave is not located in a counterelectrode, not using 2 double wave, neither of the cases can demonstrate effectiveness of this invention.

[0022] electrodes [in / the filter concerning this invention is equipped with the plurality of the piezo resonator concerning this invention, and / those piezo resonators] -- the configuration of a filter circuit -- connection -- it is a filter.

[0023] Moreover, the filter concerning this invention is a filter which comes to connect the piezo resonator concerning this invention with plurality and a ladder mold.

[0024] The duplexer concerning this invention is constituted using the filter concerning above-mentioned this invention.

[0025] The electronic communication equipment concerning this invention is equipped with one or the plurality of a piezo resonator concerning this invention, and uses those piezo resonators for electronic communication link actuation.

[0026]

[Embodiment of the Invention] Hereafter, it explains based on the gestalt of the operation which shows the detail of this invention to a drawing.

[0027] (Basic structure of a piezo resonator) With reference to drawing 1 , the basic structure of the piezo resonator of the gestalt of this operation is explained.

[0028] 1 shows the whole piezo resonator. A piezo resonator 1 is a thickness longitudinal-oscillation mold, and is equipped with a substrate 2, diaphram 3, and the oscillating part 4.

[0029] It consists of Si (silicon) and a substrate 2 has the opening 5 which penetrates a front rear face.

[0030] Diaphram 3 consists of SiO2 (silicon oxide) thin film as the outside thin film section, and said opening 5 is formed in it on this substrate 2 with the wrap gestalt.

[0031] The oscillating part 4 is formed on diaphram 3, and consists of inside thin film section 4c of one or more layers which was infixed between the counterelectrode of a vertical pair which consists of up electrode 4b and lower electrode 4a, and up electrode 4b and lower electrode 4a and which contains a piezoelectric film at least.

[0032] Both the counterelectrodes 4a and 4b consist of aluminum (aluminum).

[0033] Inside thin film section 4c consists for example, of a ZnO (zinc oxide) thin film.

[0034] (Example of manufacture of a piezo resonator) The example of manufacture of the piezo resonator of the above-mentioned structure is explained briefly. Both sides of a substrate 2 are oxidized thermally and thermal oxidation SiO2 thin film is formed. Thermal oxidation SiO2 thin film by the side of the front face of a substrate 2 serves as diaphram 3. Corresponding to said opening 5, patterning of the thermal oxidation SiO2 thin film by the side of the rear face of a substrate 2 is carried out using the photolithography method. The rear-face side of a substrate 2 is exposed by this. Anisotropic etching is carried out using lye to the rear face of this exposed substrate 2. This etching forms

opening 5 in a substrate 2 because even SiO2 thin film by the side of the front face of a substrate 2 reaches. Subsequently, lower electrode 4a is formed by lift-off vacuum evaporationo on the diaphram 3 which consists of SiO2 thin film of substrate 2 front face. Subsequently, inside thin film section 4c which consists of a ZnO thin film is formed using the membrane formation technique of the sputtering method or others on this lower electrode 4a and diaphram 3. Subsequently, up electrode 4b is formed by lift-off vacuum evaporationo on this inside thin film section 4c.

[0035] Manufacture of a piezo resonator 1 is completed by the above.

[0036] (The description structure of a piezo resonator) And with the gestalt of this operation, in the above configuration, it shall vibrate by the oscillation mode of 2 double wave equipped with the gestalt shown by the drawing 1 destructive line to a fundamental wave, and up electrode 4b and lower electrode 4a are prepared [1st] in the location of the antinode of an outline and 2 double wave. The knot of this 2 double wave exists in inside-and-outside both the thin film section 3 and 4c.

[0037] Since the antinode of 2 double wave is made the gestalt which exists in up electrode 4b and lower electrode 4a by this, the loss of the resonance energy in Electrodes 4a and 4b decreases, and the resonance characteristic becomes good by it.

[0038] the gestalt of this operation -- the 2nd diaphram 3 and the oscillating part 4 -- let each thin film of each be the combination which has the resonance frequency temperature coefficient of an opposite sign mutually. When the thickness ratio of ti and both thin films is made into r=to/ti for the thickness of a ZnO thin film [in / for the thickness of SiO2 thin film which is moreover diaphram 3 / to and the oscillating part 4], said thickness ratio r is set as the value which carries out the resonance frequency temperature coefficient of the piezo-resonator 1 whole concerned near zero.

[0039] Said 2nd [the] is explained with reference to drawing 2 .

[0040] In drawing 2 , an axis of abscissa is said thickness ratio r, and an axis of ordinate shows the resonance frequency temperature coefficient TCF. Moreover,

** shows a fundamental wave and ** shows 2 double wave. And the thickness ratio r of each thin film is set up so that the oscillating part 4 in the gestalt of this operation may be excited by the thickness length resonance mode by 2 double wave, and let the thickness ratio r be the range of 0.6-1.3.

[0041] The resonance frequency temperature coefficient TCF becomes that the thickness ratio r is this range with +10--10ppm/degree C mostly. Therefore, the resonance frequency temperature coefficient TCF can be mostly set as zero by setup of said within the limits of the thickness ratio r. It can be made to stabilize to the temperature change of the oscillation frequency in a piezo resonator 1 by this.

[0042] In this case, it is because to be able to bring a resonance frequency temperature coefficient close to zero by said thickness ratio r adjustment is used as SiO2 thin film with which the outside thin film section 3 has a forward resonance frequency temperature coefficient and it considers as the ZnO thin film with which inside thin film section 4c has a negative resonance frequency temperature coefficient. That is, if thickness to of the outside thin film section 3 which has the forward resonance frequency temperature coefficient TCF is enlarged to inside thin film section 4c which has the negative resonance frequency temperature coefficient TCF and the thickness ratio r is enlarged one or more when the thickness ratio r is 1 in drawing 2 , the resonance frequency temperature coefficient TCF will approach [the thickness ratio r] zero up to the 1.3 neighborhoods. Furthermore, if thickness to of the outside thin film section 3 is enlarged and the thickness ratio r becomes 1.3 or more, the resonance frequency temperature coefficient TCF will separate from zero, and will become large at a plus side. Moreover, when making small thickness to of the outside thin film section 3 and making the thickness ratio r small, the resonance frequency temperature coefficient TCF approaches zero up to the 0.6 neighborhoods. Furthermore, if thickness to of the outside thin film section 3 is made small and the thickness ratio r is made or less into 0.6, the resonance frequency temperature coefficient TCF will separate from zero, and will become large at a

plus side.

[0043] Thus, it can be made to stabilize to the temperature change of the resonance frequency in a piezo resonator 1 with the gestalt of this operation by adjusting the resonance frequency temperature coefficient TCF to zero mostly by setup of the thickness ratio r.

[0044] This invention is not limited to an above-mentioned operation gestalt, and can consider various application and deformation.

[0045] In addition, since it is premised on those all positioning the antinode of 2 double wave mostly with the following operation gestalten to using 2 double wave, up electrode 4b, and lower electrode 4a in this case, the temperature change of the resonance frequency shown by drawing 2 can use few fields by thickness ratio adjustment with the outside thin film section 3 and inside thin film section 4c.

[0046] (1) Although it was 2 double wave with the operation gestalt of drawing 1 , it is good as a thing which shall not be limited to this and shall vibrate by the oscillation mode of a wave (however, n two or more integers) n times and by which up electrode 4b and lower electrode 4a are prepared in the outline and the location of the antinode of a n time wave.

[0047] (2) As drawing 3 shows, it is good also considering the outside thin film section 3 as two-layer structure of thermal oxidation SiO2 film 3a and SiN(silicon nitride)3b.

[0048] since it consists of two-layer film 3a and 3b by which resonance frequency temperature coefficients differ in the case of this outside thin film section 3 -- said both film 3a and 3b -- the resonance frequency temperature coefficient of the outside thin film section 3 whole can be adjusted now by changing each thickness ratio suitably. By this adjustment, the rate of a temperature change of the resonance frequency of the piezo-resonator 1 whole can be made small, and the stability over a temperature change can be raised.

[0049] (3) As drawing 4 shows, it is good also as 3d [of SiO2 film which formed the outside thin film section 3 by thermal oxidation SiO2 film 3c and the spatter] two-layer structure.

[0050] According to the configuration of this outside thin film section 3, the temperature characteristic of the resonance frequency of said both film 3c which constitutes the outside thin film section 3, and 3d of the whole can be adjusted, and the temperature characteristic of the resonance frequency of inside thin film section 4c can be compensated.

[0051] (4) As drawing 5 shows, it is good also considering inside thin film section 4c as two-layer structure of the AlN (alumimium nitride) film 4c1 and the ZnO film 4c2.

[0052] According to the configuration of this inside thin film section 4c, the AlN film 4c1 has a forward resonance frequency temperature coefficient, and the ZnO film 4c2 has a negative resonance frequency temperature coefficient. Therefore, inside thin film section 4c which compensates the resonance frequency temperature coefficient of the outside thin film section 3 which consists of thermal oxidation SiO2 according to the two-layer structure of the AlN film 4c1 and the ZnO film 4c2, and brings the resonance frequency temperature coefficient of the piezo-resonator 1 whole close to zero can be obtained. Consequently, a piezo resonator 1 becomes that by which the temperature characteristic was small stabilized in the resonance frequency temperature coefficient.

[0053] (5) As drawing 6 shows, make the outside thin film section 3 into 3d [of SiO2 film which formed membranes by thermal oxidation SiO2 film 3c and the spatter] two-layer structure, and it is good also considering inside thin film section 4c as two-layer structure of the AlN film 4c1 and the ZnO film 4c2. If it carries out like this, the same operation effectiveness as the above can be attained to coincidence.

[0054] (6) As drawing 7 shows, the outside thin film section 3 may be consisted of from SiN film, and inside thin film section 4c may consist of AlN film. Also in this case, the operation effectiveness of the above (3) and (4) can be attained to coincidence.

[0055] (7) As drawing 8 shows, make the outside thin film section 3 into AlN film 3e and 3f [of 2Oaluminum3 (aluminum oxide) film] two-layer structure, and it is

good also considering inside thin film section 4c as monolayer structure of AlN. Also in this case, the operation effectiveness of the above (3) and (4) can be attained to coincidence.

[0056] (8) It is good as what consists or more of at least one of the thin film which, in addition, uses PZT (titanic-acid lead zirconate) as a principal component besides the thin film with which inside thin film section 4c in an oscillating part uses ZnO as a principal component, and the thin film which uses AlN as a principal component, the thin film which uses PT (lead titanate) as a principal component, and the thin films which use BT (barium titanate) as a principal component.

[0057] (9) The piezo resonator 1 of the gestalt of this operation can be used, incorporating it as a filter element of pi mold ladder filter as shown by drawing 9 (a), an L type ladder filter as shown by drawing 9 (b), T mold ladder filter as shown by drawing 9 (c), an L type ladder filter as shown by drawing 10 (a), and an L type ladder filter as shown in drawing 10 (b). In the case of such a filter, it becomes the thing of the filter shape stabilized to the temperature change. In addition, such each filter can form two or more piezo resonators 1 mentioned above on a substrate 2, and can complete the filter by which stability was carried out in the operating characteristic over a surrounding temperature change by connecting each electrode for each piezo-resonator 1 on these substrates 2.

[0058] (10) In addition to this, by the cellular phone, wireless LAN, or being carried in all various electronic communication equipment, the piezo resonator 1 of the gestalt of this operation can stabilize the operating characteristic over a surrounding temperature change, when using it for electronic communication link actuation of the electronic communication equipment concerned.

[0059] (11) The piezo resonator 1 of the gestalt of this operation may be used as a component of the duplexer carried in communication equipment etc. As this duplexer 31 is shown in drawing 11 , the antenna terminal 32, the receiving-side terminal 33, and the transmitting-side terminal 34 are formed. This duplexer 31 has the composition that a filter as shown by the piezo resonator or the above (9)

concerning this invention which allows only passage of the RF signal of a necessary frequency band between the receiving-side terminal 33 and the transmitting-side terminal 34, and the antenna terminal 32 is contained.
[0060] (12) As a modification of the piezo resonator concerning this invention, the thing of a configuration of being shown in drawing 12 may be used. While the piezo resonator 51 shown in drawing 12 forms a crevice 53 in the silicon substrate 52 bottom, the diaphram 54 as the outside thin film section which is in a wrap condition and consists silicon substrate 52 top face and its crevice 53 of two-layer [of thermal oxidation SiO2 film 54a and SiN (silicon nitride) film 54b] is formed. The oscillating part 55 is formed on this diaphram 54. This oscillating part 55 consists of the inside thin film section 57 which was put between the counterelectrode, and this up electrode 58 and the lower electrode 56 of the vertical pair which consists of an up electrode 58 and a lower electrode 56 and which contains one or more layers of piezoelectric films at least.
[0061]
[Effect of the Invention] As explained above, according to this invention, are formed in the substrate and said substrate. In the piezo resonator which has the oscillating section of the structure which the up electrode and lower electrode of a pair are made to counter at least, and faces across the vertical side of the inside thin film section which has the piezo-electric thin film of at least one or more layers and which prepared two or more resonators While having the outside thin film section containing a piezo-electric thin film or a dielectric film of one or more layers under said lower electrode Since it vibrates by the oscillation mode of a wave (however, n two or more integers) n times and said up electrode and the lower electrode are prepared in the outline and the location of the antinode of said n time wave, said oscillating section can reduce the loss of the resonance energy in an electrode. And by this invention, since a thickness ratio field where a resonance frequency temperature coefficient is not sharply changed even if it changes somewhat the thickness ratio of each of said thin film section since it shall vibrate by the oscillation mode of a wave n times exists,

stability of the resonance frequency is carried out to a temperature change by setting a thickness ratio as the field.

[Translation done.]

* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The sectional view of the piezo resonator concerning the operation gestalt of this invention
[Drawing 2] The property Fig. of the thickness ratio and resonance frequency temperature coefficient in the piezo resonator of drawing 1
[Drawing 3] The sectional view of the piezo resonator concerning other operation gestalten of this invention
[Drawing 4] The sectional view of the piezo resonator concerning the operation gestalt of further others of this invention
[Drawing 5] The sectional view of the piezo resonator concerning the operation gestalt of further others of this invention
[Drawing 6] The sectional view of the piezo resonator concerning the operation gestalt of further others of this invention
[Drawing 7] The sectional view of the piezo resonator concerning the operation

gestalt of further others of this invention

[Drawing 8] The sectional view of the piezo resonator concerning the operation gestalt of further others of this invention

[Drawing 9] The circuit diagram of the filter using the piezo resonator of this invention

[Drawing 10] The circuit diagram of the filter using the piezo resonator of this invention

[Drawing 11] The approximate account Fig. of the duplexer using the piezo resonator of this invention

[Drawing 12] The sectional view of the piezo resonator concerning the operation gestalt of further others of this invention

[Description of Notations]

1 Piezo Resonator

2 Substrate

3 Diaphram

4 Oscillating Part

4a Lower electrode

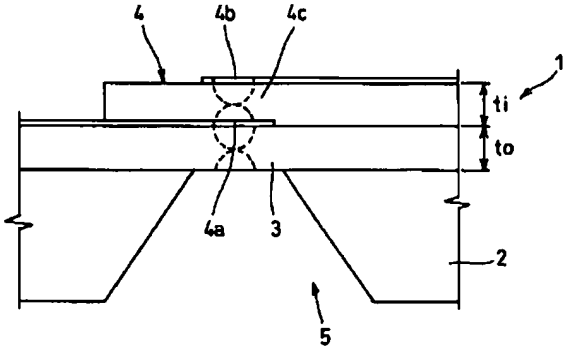
4b Up electrode

4c Piezoelectric film

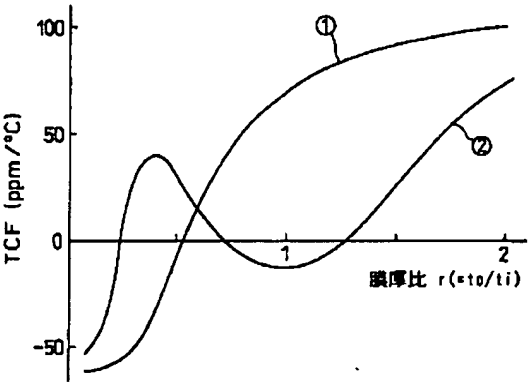
[Translation done.]

DRAWINGS

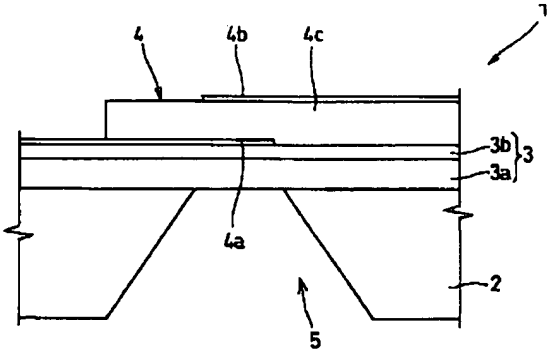
[Drawing 1]



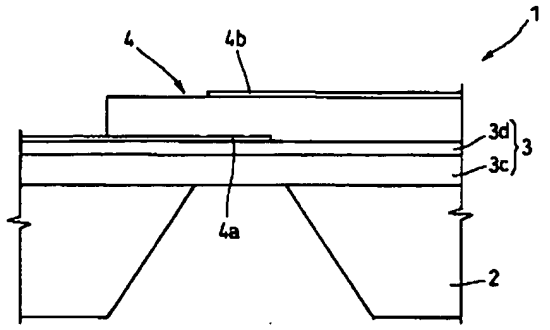
[Drawing 2]



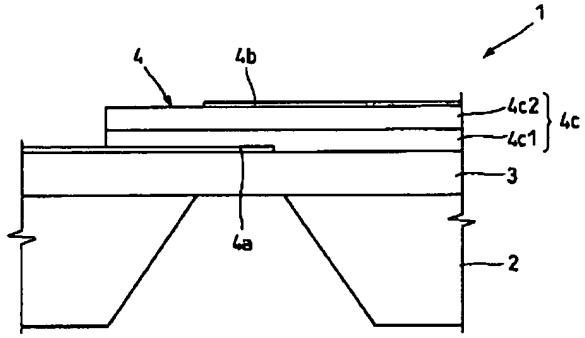
[Drawing 3]



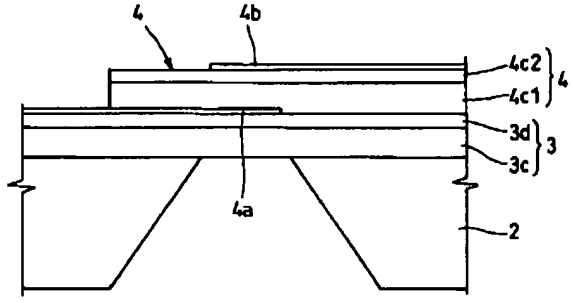
[Drawing 4]



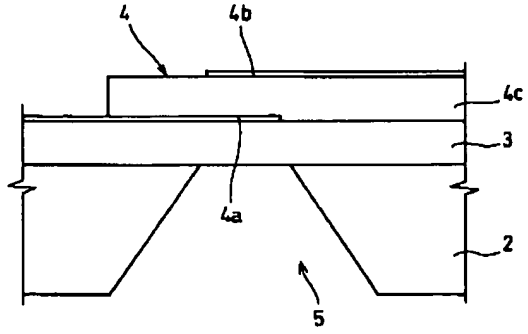
[Drawing 5]



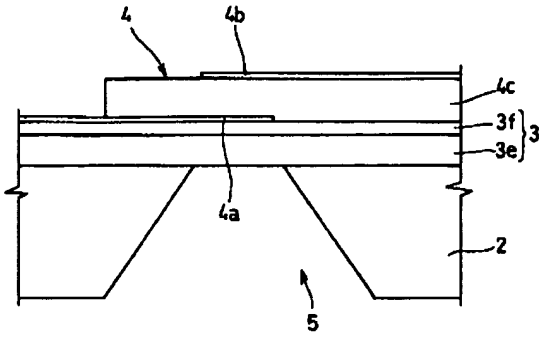
[Drawing 6]



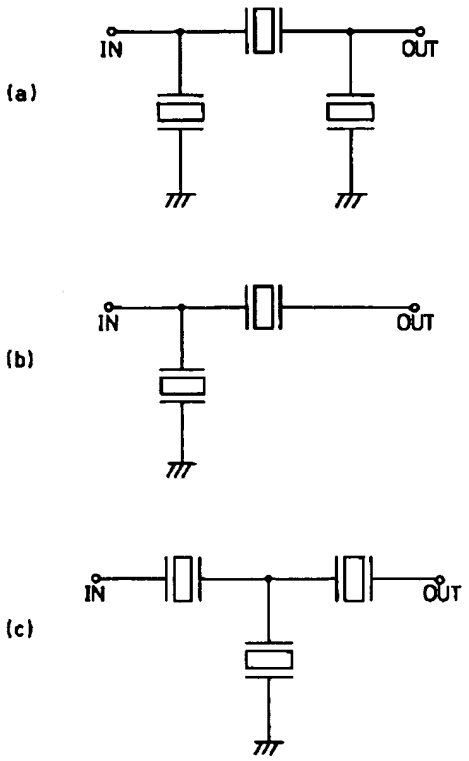
[Drawing 7]



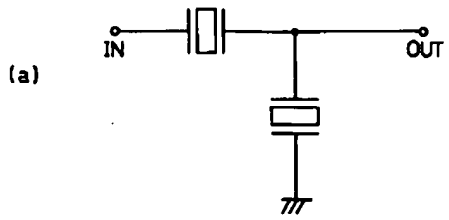
[Drawing 8]

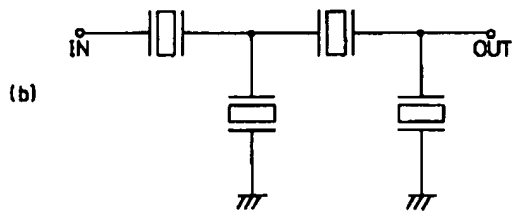


[Drawing 9]

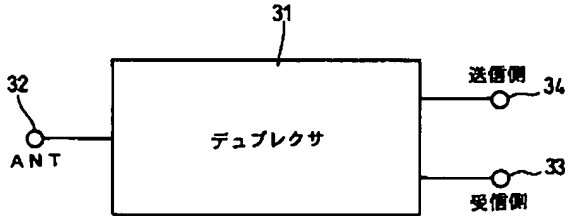


[Drawing 10]

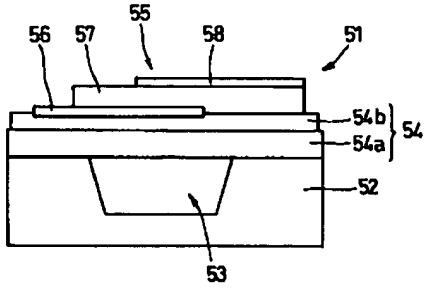




[Drawing 11]



[Drawing 12]



[Translation done.]

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2003-087085
(43)Date of publication of application : 20.03.2003

(51)Int.Cl. H03H 9/17
H01L 41/08
H01L 41/09
H01L 41/18

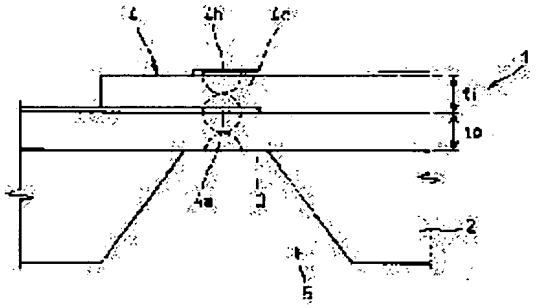
(21)Application number : 2002-139863
(22)Date of filing : 15.05.2002

(71)Applicant : MURATA MFG CO LTD
(72)Inventor : TAKEUCHI MASAKI
YAMADA HAJIME
GOTO YOSHIHIKO
NOMURA TADASHI
YOSHINO YUKIO

(30)Priority
Priority number : 2001202135 Priority date : 03.07.2001 Priority country : JP

(54) PIEZOELECTRIC RESONATOR, FILTER AND ELECTRONIC COMMUNICATIONS EQUIPMENT

(57)Abstract:
PROBLEM TO BE SOLVED: To reduce a loss of a resonance energy at an electrode and to make the stability of a resonance frequency proper with respect to temperature changes.
SOLUTION: A piezoelectric resonator has a substrate 2, and a plurality of resonators formed on the substrate 2, each having a transducer 4 of a structure, in which at least a pair of upper electrode 4b and a lower electrode 4a, arranged opposed and sandwiched by the upper and lower surfaces of an inside thin film, having at least one or more piezoelectric thin film. The piezoelectric resonator further comprises one or more outside thin film 4c, including a piezoelectric thin film or a dielectric thin film under the lower electrode 4a, in such a manner that the transducer 4 oscillates in an oscillation mode of an n-fold wave (where n is an integer of 2 or larger) and the electrodes 4b and 4a are provided at positions of the antinodes of substantially n-fold waves.



LEGAL STATUS

[Date of request for examination] 26.09.2003
[Date of sending the examiner's decision of rejection]
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]
[Number of appeal against examiner's decision of

rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

(19)日本国特許庁(JP)　(12)公開特許公報（A）　(11)特許出願公開番号

特開２００３－８７０８５

（Ｐ２００３－８７０８５Ａ）

(43)公開日　平成15年3月20日(2003.3.20)

(51)Int.Cl.⁷	識別記号	FI		テーマコード(参考)
Ｈ０３Ｈ　9/17		Ｈ０３Ｈ　9/17	Ｆ	5J108
Ｈ０１Ｌ　41/08		Ｈ０１Ｌ　41/08	Ｄ	
41/09		41/18	１０１　Ｚ	
41/18		41/08	Ｕ	

審査請求　未請求　請求項の数１０　ＯＬ　（全８頁）

(21)出願番号　特願2002-139863(P2002-139863)

(22)出願日　平成14年5月15日(2002.5.15)

(31)優先権主張番号　特願2001-202135(P2001-202135)

(32)優先日　平成13年7月3日(2001.7.3)

(33)優先権主張国　日本（ＪＰ）

(71)出願人　000006231
株式会社村田製作所
京都府長岡京市天神二丁目26番10号

(72)発明者　竹内　雅樹
京都府長岡京市天神二丁目26番10号　株式会社村田製作所内

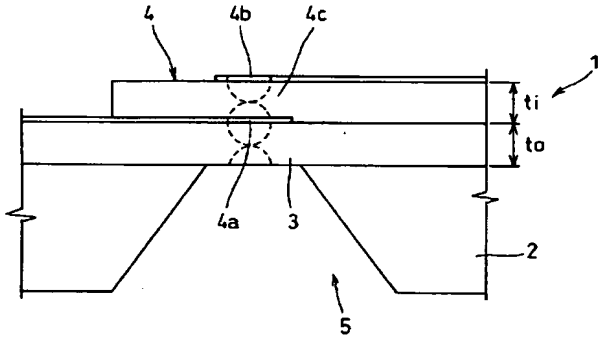
(72)発明者　山田　一
京都府長岡京市天神二丁目26番10号　株式会社村田製作所内

(74)代理人　100086737
弁理士　岡田　和秀

最終頁に続く

(54)【発明の名称】圧電共振子、フィルタおよび電子通信機器

(57)【要約】
【課題】電極での共振エネルギーのロス少なく、かつ、共振周波数の温度変化に対する安定性を良好にする。
【解決手段】基板２と、基板２に形成されている、少なくとも１層以上の圧電薄膜を有する内側薄膜部の上下面を少なくとも一対の上部電極４ｂ及び下部電極４ａを対向させて挟む構造の振動部４とを有する、共振子を複数設けた圧電共振子において、下部電極４ａの下に、圧電薄膜または誘電薄膜を含む１層以上の外側薄膜部４ｃを有するとともに、振動部４はｎ倍波（ただし、ｎは２以上の整数）の振動モードで振動し、且つ上部電極４ｂ及び下部電極４ａが、概略、ｎ倍波の腹の位置に設けられている。



1

【特許請求の範囲】

【請求項１】基板と、前記基板に形成されている、少なくとも１層以上の圧電薄膜を有する内側薄膜部の上下面を少なくとも一対の上部電極及び下部電極を対向させて挟む構造の振動部とを有する、共振子を複数設けた圧電共振子において、

前記下部電極の下に、圧電薄膜または誘電薄膜を含む１層以上の外側薄膜部を有するとともに、前記振動部はｎ倍波（ただし、ｎは２以上の整数）の振動モードで振動し、且つ前記上部電極及び下部電極が、概略、前記ｎ倍波の腹の位置に設けられている、ことを特徴とする圧電共振子。

【請求項２】請求項１に記載の圧電共振子において、

前記ｎ倍波が、２倍波とされて、前記外側薄膜部の膜厚をｔｏ、前記内側薄膜部の膜厚をｔｉ、両薄膜部の膜厚比をｒ＝ｔｏ／ｔｉとしたとき、前記膜厚比ｒが、当該圧電共振子全体の共振周波数温度係数をゼロ付近にする値に設定されている、ことを特徴とする圧電共振子。

【請求項３】請求項１または２に記載の圧電共振子において、

前記内側薄膜部もしくは外側薄膜部の少なくとも一方で各薄膜が、互いに異なる共振周波数温度係数を有する組み合わせとされている、ことを特徴とする圧電共振子。

【請求項４】請求項１ないし３のいずれかに記載の圧電共振子において、

前記外側薄膜部が、SiO_2薄膜を主成分とする薄膜、ＳｉＮ薄膜を主成分とする薄膜、Al_2O_3薄膜を主成分とする薄膜のうちの少なくとも１つ以上からなる、ことを特徴とする圧電共振子。

【請求項５】請求項１ないし４のいずれかに記載の圧電共振子において、

前記内側薄膜部が、ＺｎＯを主成分とする薄膜、ＡｌＮを主成分とする薄膜、チタン酸ジルコン酸鉛を主成分とする薄膜、チタン酸鉛を主成分とする薄膜、チタン酸バリウムを主成分とする薄膜のうちの少なくとも１つ以上からなる、ことを特徴とする圧電共振子。

【請求項６】請求項１ないし５のいずれかに記載の圧電共振子において、

前記基板は開口部もしくは凹部を有し、前記開口部もしくは凹部上に前記振動部が形成されていることを特徴とする圧電共振子。

【請求項７】請求項１ないし６のいずれかに記載の圧電共振子の複数を備え、それらの圧電共振子における電極同士をフィルタ回路の構成に接続してなる、ことを特徴とするフィルタ。

【請求項８】請求項１ないし６のいずれかに記載の圧電共振子を複数、梯子型に接続してなることを特徴とするフィルタ。

【請求項９】請求項７または８に記載のフィルタを用いて構成されることを特徴とするデュプレクサ。

2

【請求項１０】請求項１ないし６のいずれかに記載の圧電共振子の１つないしは複数を備え、それらの圧電共振子を電子通信動作に使用する、ことを特徴とする電子通信機器。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、圧電材料や誘電材料を薄膜にして多層構造として振動部位を形成する圧電共振子に係り、より詳しくは、フィルタや発振子などに使用されて、ＶＨＦ帯、ＵＨＦ帯、さらにそれ以上の超高周波帯において厚み縦振動する圧電共振子に関する。本発明はまた、この圧電共振子を用いたフィルタおよび電子通信機器に関する。

【０００２】

【従来の技術】厚み縦振動を利用した圧電共振子の場合、その共振周波数が圧電膜の厚さに反比例する関係にあることを利用して、電極間に極めて膜厚の薄い圧電膜を介装した形態にして超高周波数帯域で共振応答を得るものがある。

【０００３】このような圧電共振子において、表裏面を貫通した開口を有する基板と、前記開口を覆う形態で該基板上に設けられたSiO_2薄膜からなるダイヤフラムと、前記ダイヤフラム上に設けられた一対の対向電極間にＺｎＯ薄膜を介装してなる振動部位とを備えた厚み縦振動型のものがある。

【０００４】そして、この種の圧電共振子には、上下一対の電極に圧電膜を挟んだ構造として、基本波の腹を電極に存在する形態として電極での共振エネルギのロスをなくしてその共振特性を良好にしたものがある。

【０００５】

【発明が解決しようとする課題】しかしながら、上記従来の圧電共振子の場合、基本波を用いていたから、共振エネルギのロスが少なくなるとしても、基本波の場合、前記SiO_2薄膜とＺｎＯ薄膜との膜厚比変動で共振周波数温度係数が大きく変動するために、共振周波数が温度変化で大きく変化しやすく、したがって、温度変化に対する共振周波数の安定性が低いものである。

【０００６】したがって、本発明は、電極での共振エネルギーのロスを低減し、かつ、温度変化に対する共振周波数の安定性を良好にすることを解決すべき課題としている。

【０００７】

【課題を解決するための手段】本発明は、基板と、前記基板に形成されている、少なくとも１層以上の圧電薄膜を有する内側薄膜部の上下面を少なくとも一対の上部電極及び下部電極を対向させて挟む構造の振動部とを有する、共振子を複数設けた圧電共振子において、前記下部電極の下に、圧電薄膜または誘電薄膜を含む１層以上の外側薄膜部を有するとともに、前記振動部はｎ倍波（ただし、ｎは２以上の整数）の振動モードで振動し、且つ

前記上部電極及び下部電極が、概略、前記ｎ倍波の腹の位置に設けられていることを特徴とする。

【０００８】本発明によると、上部電極及び下部電極が、概略、ｎ倍波の腹の位置に設けられているから、それら電極での共振エネルギのロスを低減できる。そして、本発明では、ｎ倍波の振動モードで振動するものとされていることにより、前記各薄膜部の膜厚比が多少変動しても共振周波数温度係数が大きく変動するようなことがない膜厚比領域が存在するから、膜厚比をその領域に設定することで温度変化に対して共振周波数を安定させられる。

【０００９】本発明は、好ましくは、前記ｎ倍波が、２倍波とされて、前記外側薄膜部の膜厚をｔｏ、前記内側薄膜部の膜厚をｔｉ、両薄膜部の膜厚比をｒ＝ｔｏ／ｔｉとしたとき、前記膜厚比ｒが、当該圧電共振子全体の共振周波数温度係数をゼロ付近にする値に設定されている。

【００１０】こうした場合、ｎ倍波が２倍波とされることで、さらに効果的に、温度変化に対して共振周波数を安定させられる。

【００１１】本発明は、さらに好ましくは、前記内側薄膜部もしくは外側薄膜部の少なくとも一方で各薄膜が、互いに異なる共振周波数温度係数を有する組み合わせとされている。

【００１２】この組み合わせは、内側薄膜部が複数の薄膜からなるときは、内側薄膜部を構成する各薄膜間での組み合わせ、外側薄膜部が複数の薄膜からなるときは、外側薄膜部を構成する各薄膜間での組み合わせ、内側薄膜部と外側薄膜部それぞれを構成する各薄膜間での組み合わせのいずれも含む。

【００１３】こうした場合、さらに効果的に当該圧電共振子全体の共振周波数温度係数をゼロ付近に設定できるから、温度変化に対して共振周波数を一層安定させることができる。

【００１４】本発明は、さらに好ましくは、前記外側薄膜部が、SiO_2薄膜を主成分とする薄膜、ＳｉＮ薄膜を主成分とする薄膜、Al_2O_3薄膜を主成分とする薄膜のうちの少なくとも１つ以上からなる。

【００１５】本発明は、さらに好ましくは、前記内側薄膜部が、ＺｎＯを主成分とする薄膜、ＡｌＮを主成分とする薄膜、チタン酸ジルコン酸鉛（ＰＺＴ）を主成分とする薄膜、チタン酸鉛（ＰＴ）を主成分とする薄膜、チタン酸バリウム（ＢＴ）を主成分とする薄膜のうちの少なくとも１つ以上からなる。

【００１６】本発明は、さらに好ましくは、前記基板は開口部もしくは凹部を有し、前記開口部もしくは凹部上に前記振動部が形成されている。ここで、開口部とは、基板の表裏面を貫通した状態の空間部をいう。凹部は、基板の一面側に有底状に凹み形成された空間部をいう。このように、開口部もしくは凹部上に振動部が形成されていることによって、共振特性が向上する。

【００１７】以上のことより、本発明によると、膜厚の変動に対して共振周波数温度係数の小さいつまり共振周波数の温度変化に対する変動を小さく抑制でき、温度変化に対して共振応答が極めて安定した圧電共振子を提供することができるものとなる。

【００１８】なお、特開２００１－２０３５５８号公報には、上下一対の電極間に、負の共振周波数温度係数を有する圧電膜と、正の共振周波数温度係数を有する圧電膜とを挟んだ構造として、圧電共振子全体としての共振周波数温度係数をゼロに近づけて温度変化に対する共振応答の安定化を図ることが開示されている。

【００１９】また、ＥＰ０９６３０４０Ａ２明細書には、上下一対の電極に圧電膜を挟んだ構造として、共振波の腹を電極に存在する形態として電極での共振エネルギのロスをなくしてその共振特性を良好にすることが開示されている。

【００２０】また、特公平１－４８６９４号公報には、上下一対の電極間に一対の圧電膜間に該圧電膜と異符号の薄膜をその厚み方向中央に積層して共振周波数の温度特性を良好にすることが開示されている。

【００２１】いずれの場合も、本発明のように、２倍波を用いておらず、かつ、振動波の腹が対向電極に位置していないから、本発明の効果を発揮することができない。

【００２２】本発明に係るフィルタは、本発明に係る圧電共振子の複数を備え、それらの圧電共振子における電極同士をフィルタ回路の構成に接続なるフィルタである。

【００２３】また、本発明に係るフィルタは、本発明に係る圧電共振子を複数、梯子型に接続してなるフィルタである。

【００２４】本発明に係るデュプレクサは、上記本発明に係るフィルタを用いて構成される。

【００２５】本発明に係る電子通信機器は、本発明に係る圧電共振子の１つないしは複数を備え、それらの圧電共振子を電子通信動作に使用する。

【００２６】

【発明の実施の形態】以下、本発明の詳細を図面に示す実施の形態に基づいて説明する。

【００２７】(圧電共振子の基本構造)図１を参照して、本実施の形態の圧電共振子の基本構造を説明する。

【００２８】１は、その圧電共振子全体を示す。圧電共振子１は、厚み縦振動型であって、基板２と、ダイヤフラム３と、振動部位４とを備える。

【００２９】基板２は、例えば、Ｓｉ(シリコン)からなり、表裏面を貫通する開口部５を有する。

【００３０】ダイヤフラム３は、外側薄膜部としてＳｉO_2(酸化シリコン)薄膜からなり、前記開口部５を覆う形態で該基板２上に設けられている。

【００３１】振動部位４は、ダイヤフラム３上に設けられており、上部電極４ｂと下部電極４ａとからなる上下一対の対向電極と、上部電極４ｂ及び下部電極４ａの間に介装された少なくとも圧電膜を含む１層以上の内側薄膜部４ｃとからなる。

【００３２】対向電極４ａ，４ｂは、共に、例えば、Ａｌ(アルミニウム)から構成されている。

【００３３】内側薄膜部４ｃは、例えば、ＺｎＯ(酸化亜鉛)薄膜からなる。

【００３４】(圧電共振子の製造例)上記構造の圧電共振子の製造例を簡単に説明する。基板２の両面を熱酸化して熱酸化SiO_2薄膜を形成する。基板２の表面側の熱酸化SiO_2薄膜はダイヤフラム３となる。基板２の裏面側の熱酸化SiO_2薄膜は、フォトリソグラフィ法を用いて前記開口部５に対応してパターニングされる。これによって、基板２の裏面側を露出する。この露出した基板２の裏面に対してアルカリ液を用いて異方性エッチングする。このエッチングは基板２の表面側のSiO_2薄膜まで達することで基板２に開口部５を形成する。次いで、基板２表面のSiO_2薄膜よりなるダイヤフラム３上にリフトオフ蒸着により下部電極４ａを形成する。次いで、この下部電極４ａおよびダイヤフラム３上にＺｎＯ薄膜からなる内側薄膜部４ｃをスパッタリング法やその他の成膜技術を用いて形成する。次いで、この内側薄膜部４ｃ上にリフトオフ蒸着により上部電極４ｂを形成する。

【００３５】以上により圧電共振子１の製造が完了する。

【００３６】(圧電共振子の特徴構造)そして、本実施の形態では、以上の構成において、第１に、基本波に対して図１中破線で示される形態を備えた２倍波の振動モードで振動するものとされており、かつ、上部電極４ｂ及び下部電極４ａが、概略、２倍波の腹の位置に設けられている。この２倍波の節は、内外両薄膜部３，４ｃ内に存在している。

【００３７】これによって、２倍波の腹が上部電極４ｂ及び下部電極４ａに存在する形態とされているから、電極４ａ，４ｂでの共振エネルギのロスが少なくなり共振特性が良好になる。

【００３８】本実施の形態は、第２に、ダイヤフラム３と振動部位４それぞれの各薄膜が、互いに異符号の共振周波数温度係数を有する組み合わせとされている。そのうえで、ダイヤフラム３であるSiO_2薄膜の膜厚をｔｏ、振動部位４におけるＺｎＯ薄膜の膜厚をｔｉ、両薄膜の膜厚比をｒ＝ｔｏ／ｔｉとしたとき、前記膜厚比ｒが、当該圧電共振子１全体の共振周波数温度係数をゼロ付近にする値に設定されている。

【００３９】前記第２について図２を参照して説明する。

【００４０】図２において、横軸は、前記膜厚比ｒであり、縦軸は、共振周波数温度係数ＴＣＦを示す。また、①は、基本波、②は、２倍波を示す。そして、本実施の形態における振動部位４は、２倍波による厚み縦共振モードで励振されるよう各薄膜の膜厚比ｒが設定されており、その膜厚比ｒは０．６～１．３の範囲とされている。

【００４１】膜厚比ｒがこの範囲であると、共振周波数温度係数ＴＣＦはほぼ＋１０～－１０ｐｐｍ／℃となる。したがって、膜厚比ｒの前記範囲内における設定で共振周波数温度係数ＴＣＦをほぼゼロに設定することができる。これによって、圧電共振子１における振動周波数の温度変化に対して安定化させることができる。

【００４２】この場合、前記膜厚比ｒ調整で、共振周波数温度係数をゼロに近付けることができるのは、外側薄膜部３が正の共振周波数温度係数を有するSiO_2薄膜とされ、内側薄膜部４ｃが負の共振周波数温度係数を有するＺｎＯ薄膜とされているからである。つまり、図２において膜厚比ｒが１である場合において、正の共振周波数温度係数ＴＣＦを有する外側薄膜部３の膜厚ｔｏを負の共振周波数温度係数ＴＣＦを有する内側薄膜部４ｃに対して大きくして膜厚比ｒを１以上に大きくすると、膜厚比ｒが１．３付近までは共振周波数温度係数ＴＣＦがゼロに近づく。さらに、外側薄膜部３の膜厚ｔｏを大きくして膜厚比ｒが１．３以上になると、共振周波数温度係数ＴＣＦがゼロから離れてプラス側に大きくなる。また、外側薄膜部３の膜厚ｔｏを小さくして膜厚比ｒを小さくする場合、０．６付近までは共振周波数温度係数ＴＣＦがゼロに近づく。さらに、外側薄膜部３の膜厚ｔｏを小さくして膜厚比ｒを０．６以下にすると、共振周波数温度係数ＴＣＦがゼロから離れてプラス側に大きくなる。

【００４３】このようにして本実施の形態では、膜厚比ｒの設定で共振周波数温度係数ＴＣＦをほぼゼロに調整することによって、圧電共振子１における共振周波数の温度変化に対して安定化させることができる。

【００４４】本発明は、上述の実施形態に限定されるものではなく種々な応用や変形が考えられる。

【００４５】なお、この場合、以下の実施形態では、そのいずれも、２倍波を用いること、および上部電極４ｂ及び下部電極４ａに対して２倍波の腹をほぼ位置付けることを前提とするから、外側薄膜部３と内側薄膜部４ｃとの膜厚比調整で、図２で示される共振周波数の温度変化が少ない領域を使用することができる。

【００４６】(1)図１の実施形態では２倍波であったが、これに限定されるものではなく、ｎ倍波(ただし、ｎは２以上の整数)の振動モードで振動するものとされ、かつ、上部電極４ｂ及び下部電極４ａが、概略、ｎ倍波の腹の位置に設けられているものとしてよい。

【００４７】(2)図３で示すように、外側薄膜部３を熱酸化SiO_2膜３ａとＳｉＮ(窒化シリコン)３ｂとの２

層構造としてもよい。

【００４８】この外側薄膜部３の場合、共振周波数温度係数が異なる２層の膜３ａ，３ｂで構成されるから、前記両膜３ａ，３ｂそれぞれの膜厚比を適宜に変更することで、外側薄膜部３全体の共振周波数温度係数を調整することができるようになる。この調整により、圧電共振子１全体の共振周波数の温度変化率を小さくして温度変化に対しての安定性を高めることができる。

【００４９】(3) 図４で示すように、外側薄膜部３を、熱酸化SiO_2膜３ｃとスパッタ法で成膜したSiO_2膜３ｄとの２層構造としてもよい。

【００５０】この外側薄膜部３の構成によると、外側薄膜部３を構成する前記両膜３ｃ，３ｄ全体の共振周波数の温度特性を調整して、内側薄膜部４ｃの共振周波数の温度特性を補償することができる。

【００５１】(4) 図５で示すように、内側薄膜部４ｃを、ＡｌＮ(窒化アルミニウム)膜４ｃ１とＺｎＯ膜４ｃ２との２層構造としてもよい。

【００５２】この内側薄膜部４ｃの構成によると、ＡｌＮ膜４ｃ１は、正の共振周波数温度係数を有し、ＺｎＯ膜４ｃ２は、負の共振周波数温度係数を有する。そのためＡｌＮ膜４ｃ１とＺｎＯ膜４ｃ２との２層構造により熱酸化SiO_2からなる外側薄膜部３の共振周波数温度係数を補償して圧電共振子１全体の共振周波数温度係数をゼロに近付けるような内側薄膜部４ｃを得ることができる。その結果、圧電共振子１は、共振周波数温度係数を小さく温度特性が安定したものとなる。

【００５３】(5)図６で示すように、外側薄膜部３を熱酸化SiO_2膜３ｃとスパッタ法で成膜したSiO_2膜３ｄとの２層構造とし、内側薄膜部４ｃをＡｌＮ膜４ｃ１とＺｎＯ膜４ｃ２との２層構造としてもよい。こうすると、前記と同様の作用効果を同時に達成することができる。

【００５４】(6)図７で示すように、外側薄膜部３をＳｉＮ膜で、内側薄膜部４ｃをＡｌＮ膜で構成してもよい。この場合も、前記(3)(4)の作用効果を同時に達成することができる。

【００５５】(7)図８で示すように、外側薄膜部３をＡｌＮ膜３ｅとAl_2O_3(酸化アルミニウム)膜３ｆとの２層構造とし、内側薄膜部４ｃをＡｌＮの単層構造としてもよい。この場合も、前記(3)(4)の作用効果を同時に達成することができる。

【００５６】(8)なお、振動部位における内側薄膜部４ｃが、ＺｎＯを主成分とする薄膜、ＡｌＮを主成分とする薄膜以外にも、ＰＺＴ(チタン酸ジルコン酸鉛)を主成分とする薄膜、ＰＴ(チタン酸鉛)を主成分とする薄膜、ＢＴ(チタン酸バリウム)を主成分とする薄膜のうちの少なくとも１つ以上からなるものとしてよい。

【００５７】(9)本実施の形態の圧電共振子１は、図９(a)で示すようなπ型ラダーフィルタ、図９(b)で示すようなＬ型ラダーフィルタ、図９(c)で示すようなＴ型ラダーフィルタ、図１０（ａ）で示すようなＬ型ラダーフィルタ、図１０（ｂ）に示すようなＬ型ラダーフィルタのフィルタ素子として組み込んで使用することができる。このようなフィルタの場合、温度変化に対して安定したフィルタ特性のものとなる。なお、このような各フィルタは、上述した圧電共振子１を基板２上に複数設け、これら基板２上の各圧電共振子１どうしをそれぞれの電極を接続することで、周囲の温度変化に対する動作特性を安定させられたフィルタを完成することができる。

【００５８】(10)本実施の形態の圧電共振子１は、携帯電話や無線ＬＡＮやその他、あらゆる各種電子通信機器に搭載されることで、当該電子通信機器の電子通信動作に使用する場合、周囲の温度変化に対する動作特性を安定させることができる。

【００５９】（１１）本実施の形態の圧電共振子１は、通信機器などに搭載されるデュプレクサの素子として用いられても良い。このデュプレクサ３１は、図１１に示すように、アンテナ端子３２、受信側端子３３及び送信側端子３４が設けられている。このデュプレクサ３１は、受信側端子３３及び送信側端子３４と、アンテナ端子３２との間に所要周波数帯域の高周波信号の通過のみ許す本発明に係る圧電共振子または上記（９）で示されたようなフィルタが含まれる構成となっている。

【００６０】（１２）本発明に係る圧電共振子の変形例として、図１２に示す構成のものでも良い。図１２に示される圧電共振子５１は、シリコン基板５２の上側に凹部５３を形成するとともに、シリコン基板５２上面及びその凹部５３を覆う状態で、熱酸化SiO_2膜５４ａとＳｉＮ（窒化珪素）膜５４ｂとの２層から成る外側薄膜部としてのダイヤフラム５４が成膜されている。このダイヤフラム５４の上には、振動部位５５が設けられている。この振動部位５５は、上部電極５８と下部電極５６とからなる上下一対の対向電極と、この上部電極５８と下部電極５６とに挟み込まれた少なくとも圧電膜を１層以上含む内側薄膜部５７とからなる。

【００６１】

【発明の効果】以上説明したように、本発明によれば、基板と、前記基板に形成されている、少なくとも１層以上の圧電薄膜を有する内側薄膜部の上下面を少なくとも一対の上部電極及び下部電極を対向させて挟む構造の振動部とを有する、共振子を複数設けた圧電共振子において、前記下部電極の下に、圧電薄膜または誘電薄膜を含む１層以上の外側薄膜部を有するとともに、前記振動部はｎ倍波（ただし、ｎは２以上の整数）の振動モードで振動し、且つ前記上部電極及び下部電極が、概略、前記ｎ倍波の腹の位置に設けられているから、電極での共振エネルギーのロスを低減できる。そして、本発明では、ｎ倍波の振動モードで振動するものとされているから、

9

前記各薄膜部の膜厚比が多少変動しても共振周波数温度係数が大きく変動するようなことがない膜厚比領域が存在するから、膜厚比をその領域に設定することで温度変化に対して共振周波数を安定させられる。

【図面の簡単な説明】

【図１】本発明の実施形態に係る圧電共振子の断面図

【図２】図１の圧電共振子における膜厚比と共振周波数温度係数との特性図

【図３】本発明の他の実施形態に係る圧電共振子の断面図

【図４】本発明のさらに他の実施形態に係る圧電共振子の断面図

【図５】本発明のさらに他の実施形態に係る圧電共振子の断面図

【図６】本発明のさらに他の実施形態に係る圧電共振子の断面図

【図７】本発明のさらに他の実施形態に係る圧電共振子の断面図

10

【図８】本発明のさらに他の実施形態に係る圧電共振子の断面図

【図９】本発明の圧電共振子を用いたフィルタの回路図

【図１０】本発明の圧電共振子を用いたフィルタの回路図

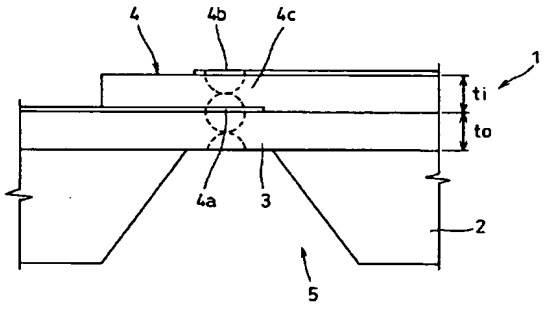
【図１１】本発明の圧電共振子を用いたデュプレクサの概略説明図

【図１２】本発明のさらに他の実施形態に係る圧電共振子の断面図

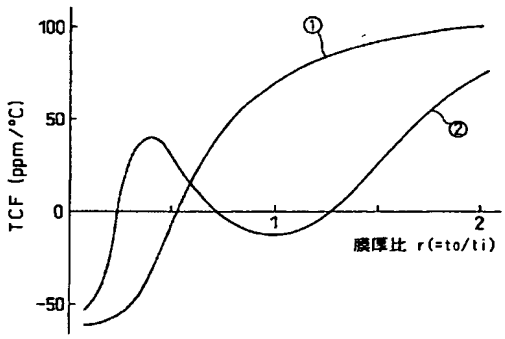
【符号の説明】

１　圧電共振子
２　基板
３　ダイヤフラム
４　振動部位
４ａ　下部電極
４ｂ　上部電極
４ｃ　圧電膜

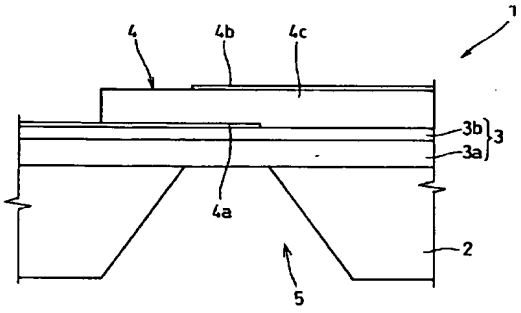
【図１】



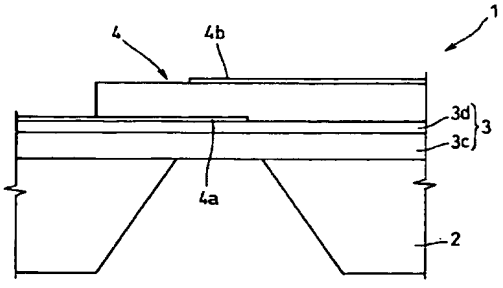
【図２】



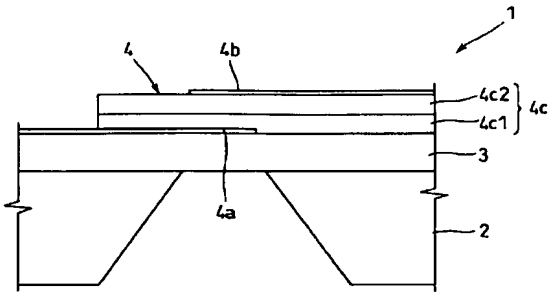
【図３】



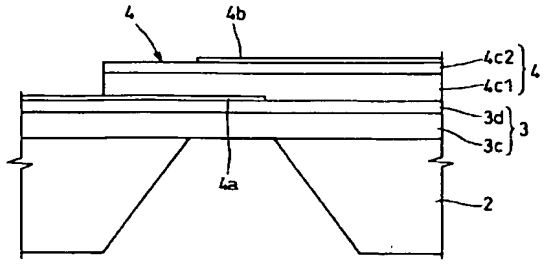
【図４】



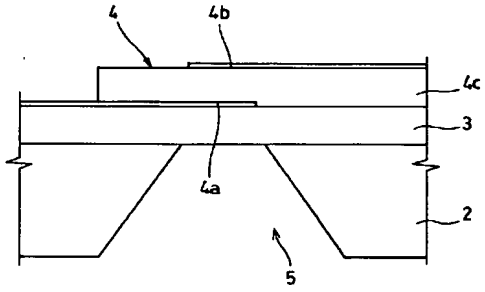
【図５】



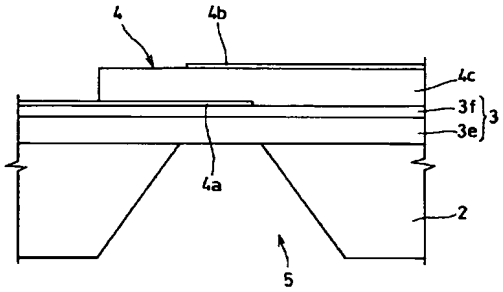
【図６】



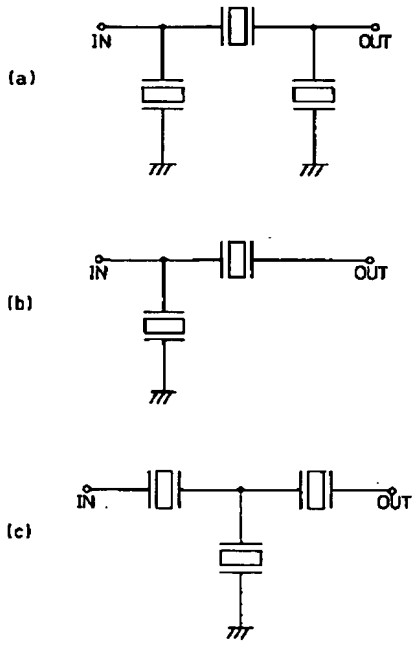
【図７】



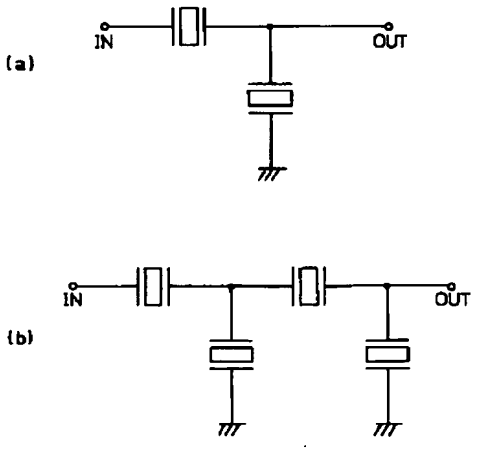
【図８】



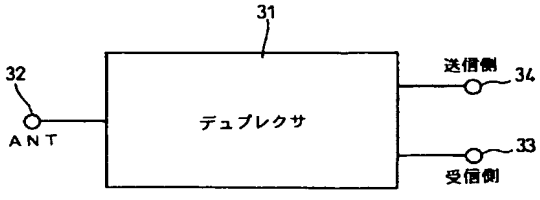
【図９】



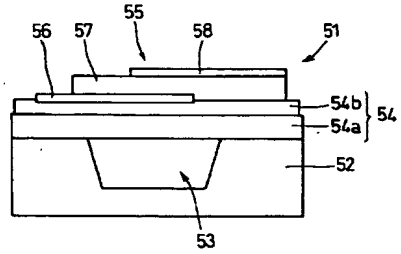
【図１０】



【図１１】



【図１２】



フロントページの続き

(72) 発明者　後藤　義彦
京都府長岡京市天神二丁目26番10号　株式会社村田製作所内
(72) 発明者　野村　忠志
京都府長岡京市天神二丁目26番10号　株式会社村田製作所内
(72) 発明者　吉野　幸夫
京都府長岡京市天神二丁目26番10号　株式会社村田製作所内

Ｆターム(参考)　5J108 AA04 AA07 BB04 BB07 BB08 CC11 CC12 DD08